(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 1 087 294 A2

(12) EUROPEAN PATENT APPLICATION

(43) Date of publication:
28.03.2001 Bulletin 2001/13

(51) Int Cl.7: G06F 9/445

(21) Application number: 00308451.4

(22) Date of filing: 27.09.2000

(84) Designated Contracting States:
AT BE CH CY DE DK ES FI FR GB GR IE IT LI LU MC NL PT SE
Designated Extension States:
AL LT LV MK RO SI

(30) Priority: 27.09.1999 US 405095

(71) Applicant: Nortel Networks Limited
Montreal, Quebec H2Y 3Y4 (CA)

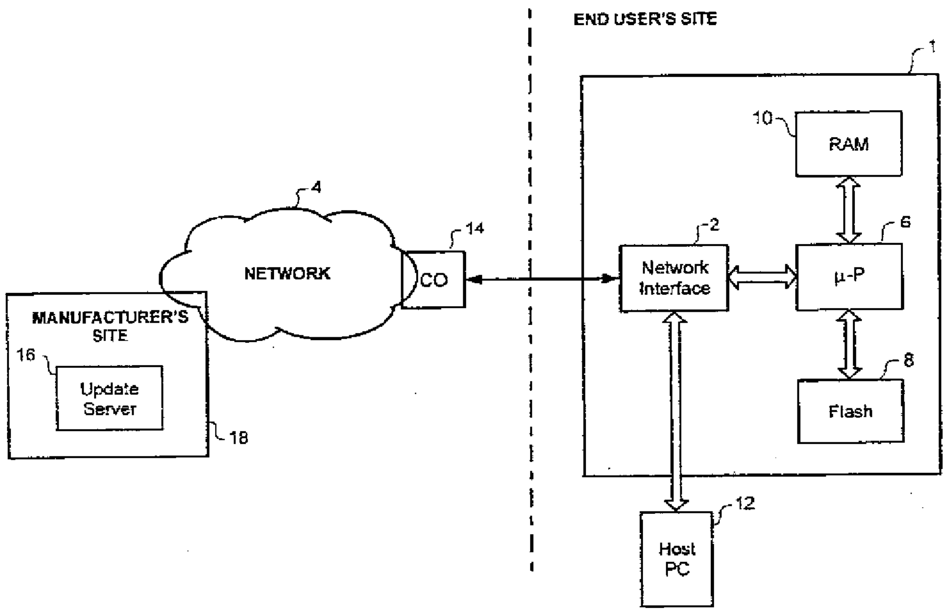
(72) Inventor: Rusmussen, John H.
Ottawa, Ontario K1Z 6B5 (CA)

(74) Representative: Lawrence, Malcolm Graham et al
Hepworth, Lawrence, Bryer & Bizley
Merlin House
Falconry Court
Baker's Lane
Epping Essex CM16 5DQ (GB)

(54) Method and apparatus of remotely updating firmware of a communication device

(57) A method and apparatus for remotely updating firmware saved in a FLASH memory of a communication device connected to a network is presented. The FLASH memory is partitioned into at least a first and a second portion. A first firmware load is stored in the first portion. During run-time of the first firmware load, at least a portion of an updated firmware load is transmitted through the network to the communication device. The transmitted portion of the updated firmware load is temporarily stored in a buffer of the communication device. At least a portion of the first firmware load is copied into a random access memory (RAM) of the communication device. Execution, from the RAM, of the copied portion of the first firmware load is triggered. Under control of the copied portion of the first firmware load, the transmitted portion of the updated firmware load is saved to the second portion of the FLASH memory.

Figure 1



Description

[0001] The present invention relates to data communication devices, and in particular to a method of remotely downloading firmware to a communication device (e.g. a modem) through a communication network, and a computer program element relating thereto. The computer program element can be embodied on a computer readable medium.

[0002] The provision of data communication services (e.g. Internet, xDSL etc.) necessarily requires the installation of a communication device (e.g. a modem connected to a host personal computer - PC) at an end-user site. Typically, the end-user is provided with a communications application (e.g. a browser) running on the host PC to control data communication sessions using a graphical user interface (GUI). The communications application interacts with the installed communication device using a high level Application Program Interface (API) to access firmware governing the low-level functionality of the communication device. Such firmware is commonly saved in a FLASH memory during manufacture of the communication device, and is run from the FLASH memory.

[0003] As in other areas of the software industry, firmware applications are not static. Rather, development is an ongoing process of improving algorithms and code to enhance the reliability and functionality of the communication device. However, while updated firmware applications can easily be loaded into new communication devices at the factory, it is difficult to provide upgrade loads to communication devices which have been already sold and delivered to the customer.

[0004] United States Patent No. 5,268,928 (Herh, et. al.) teaches a data modem with remote firmware update capabilities. According to Herh et al., the data modem is provided with a read only memory (ROM), and a battery-backed random access memory (RAM). The firmware is divided into a boot-logic which is saved in the ROM, and application logic which is stored in the battery-backed RAM. Update loads of the application logic can be downloaded to the modem during normal operation of the device and stored in the battery-backed RAM. Herh et al. require that the modem be provided with two separate memories, and further require that the data modem have additional circuitry (including a built-in battery) to ensure that the application logic is not lost when the modem is turned off. This increases the cost and complexity of the data modem. Another disadvantage of the data modem taught by Herh et al. is that the boot logic (which enables the data modem to perform its basic functions) are stored in the ROM, and thus cannot be updated during the life of the data modem.

[0005] It is preferable to store the firmware (both boot and application logic) in a FLASH memory, which is a non-volatile form of programmable memory. One of the advantages of saving the firmware in FLASH memory is that no special equipment is required to write data to the FLASH memory. The circuitry already provided on the device for normal read/write operations is sufficient. Because the FLASH memory can be used for both read and write operations, is it convenient to run the firmware from the FLASH-memory, which minimizes the requirement for RAM. Furthermore, the FLASH memory retains its information after loss of power, so battery-backup circuits are not required.

[0006] FLASH memory is readily available in standard sizes (e.g. 128 kb), and, depending on the addressing limitations of the microprocessor of the communication device, may be logically divided into frames or pages (e.g. of 32kb each). Typically, each page can be enabled (i.e. accessed for reading or writing data) individually by the microprocessor by means of an appropriate page-select signal applied to one or more page-select input pins on the FLASH memory chip. Each page is further subdivided into individually accessible blocks, which can be accessed by the microprocessor by applying appropriate address-select signals to address-select input pins on the FLASH memory chip. Conveniently, corresponding blocks of every page can be accessed using a common address-select signal, so that any desired block on any page of the FLASH memory can be uniquely accessed by applying appropriate page-select and address-select signals (in combination) to the page-select and address-select input pins of the FLASH memory chip.

[0007] During operation of the communication device, the microprocessor holds one page in enabled condition (by holding the page select signal constant), and then reads firmware application logic from blocks of the enabled page by changing the address-select signal (either incrementally or in response to jump commands embedded in application logic). Since a single address-select signal can access a corresponding block of memory on each page, changing the page-select signal (thereby enabling another page) during execution of the application logic will very likely cause erroneous operation of the communication device as the microprocessor attempts to execute the contents of a block of FLASH memory which is located on a page other than the page containing the application logic. As a safety measure to prevent this occurrence, firmware applications are typically written in such a way as to prevent the microprocessor from enabling any other page of the FLASH memory while any portion of the application logic is being run.

[0008] It is not possible to write information to a portion of the FLASH memory, while reading information from that same portion of FLASH memory. Thus when the modem is in operating mode, the firmware application is being run (therefore also read) from the FLASH memory, and it is not possible to write an updated firmware load to the FLASH memory. Where the FLASH memory is divided into pages, then during operation of the modem the page which contains the firmware application (or that part of it which is running at that time) is necessarily being held in enabled condition, which precludes saving an updated firmware load to any other page of the FLASH memory.

[0009] As a result of the above-noted problems, the method of Herh et al. cannot be used in a data modem in which the firmware is stored in a FLASH memory.

[0010] Two other methods are known for updating modem firmware. The first of these is exemplified by United States Patent No. 5,781,921 (Nichols), wherein the updated software is distributed in a removable memory device (e.g. a floppy diskette, or a memory cartridge adapted to connect to the modem). Once the removable memory device has been coupled to the modem, the updated firmware is installed under software control. The second method, which is commonly used in the software industry, requires the end user to download the updated firmware load over the communication network, and then subsequently install the updated load under software control.

[0011] Both of these methods have certain drawbacks. The use of a removable memory device is expensive, because copies of the device must be either distributed to each user (and used only once), or service technicians must be hired to perform the upgrade. Downloading updated software (e.g. through the Internet) is commonly used as a means of distributing software updates, but requires intervention by the user. Each of these methods is undesirable because each creates inconvenience for the user. Because of the inconvenience, many users will not attempt to upgrade the firmware unless forced to do so because of problems using the modem, which means that the user is already experiencing dissatisfaction with the modem. Additionally, the manufacturer of the modem is forced to rely on others to distribute and install the update loads, and thus cannot be confident that all customers' modems are operating with the latest firmware.

[0012] There therefore remains a need for a method of updating firmware of a communication device, under remote control and with minimum disruption to the user.

[0013] It is a general object of the present invention to provide a method of remotely updating firmware saved in FLASH memory, which overcomes at least some of the above-noted limitations of the prior art.

[0014] More specifically, it is an object of the invention to provide a method of remotely updating firmware saved in FLASH memory, with minimum user-perceivable disruption in the operation of the communication device.

[0015] It is a further object of the present invention to provide a method of remotely updating firmware saved in FLASH memory, in which operation of the communication device is protected in the event of a failure during an attempted update operation.

[0016] These objects are met by the combination of features defined in the main claims appended hereto. The subclaims define further advantageous features and embodiments of the present invention.

[0017] Accordingly, an aspect of the present invention provides a method of remotely updating firmware saved in a FLASH memory of a communication device connected to a network, the FLASH memory being partitioned into at least a first and a second portion, a first firmware load being stored in the first portion. During run-time of the first firmware load: at least a portion of an updated firmware load is transmitted through the network to the communication device. The transmitted portion of the updated firmware load is temporarily stored in a buffer of the communication device. At least a portion of the first firmware load is copied into a random access memory (RAM) of the communication device, and execution of the copied portion of the first firmware load from the RAM is triggered. Under control of the copied portion of the first firmware load, the transmitted portion of the updated firmware load is saved to the second portion of the FLASH memory.

[0018] Another aspect of the present invention provides an apparatus for remotely updating firmware saved in a FLASH memory of a communication device connected to a network, the FLASH memory being partitioned into at least a first and a second portion, a first firmware load being stored in the first portion, and at least a portion of an updated firmware load being transmitted through the network to the communication device. The apparatus comprises a microprocessor operative under control of the first firmware load to: copy at least a portion of the first firmware load into a random access memory (RAM) of the communication device; trigger execution of the copied portion of the first firmware load from the RAM; and save the transmitted portion of the updated firmware load to the second portion of the FLASH memory under control of the copied portion of the first firmware load.

[0019] The communication device may include a buffer for temporarily storing the transmitted portion of the updated firmware load. The portion of an updated firmware load may be transmitted through the network to the communication device by a server operatively connected to the network.

[0020] In some embodiments of the invention, the first portion may comprise a boot page, and the first firmware load may be saved in the boot page during manufacture of the communication device.

[0021] In some embodiments of the invention, the first firmware load may include a boot logic adapted to control operation of the communication device during a start-up of the communication device.

[0022] In some embodiments of the invention, an entire updated firmware load may be transmitted in a single download operation using a data channel of the communication device, and temporarily stored in an upstream buffer of the communication device. In such cases the communication device may be placed into a loop-back mode prior to transmitting the updated firmware load.

[0023] The step of copying at least a portion of the first firmware load into a random access memory (RAM) of the communication device may be performed during a start-up of the communication device.

[0024] Some embodiments of the invention further comprise preliminarily dividing the updated firmware load into a plurality of predetermined load portions. Each load portion may be transmitted in a respective download operation using a message channel of the communication device, and temporarily stored in a message buffer of the communication device. Each download operation may comprise transmitting a DnldData command including an address and the load portion as arguments. The load portion may be saved in the FLASH memory starting at an address of the FLASH memory corresponding to the address included in the DnldData command. A step of determining whether or not the load portion has been correctly saved in the FLASH memory can then be performed. When the load portion has been correctly saved in the FLASH memory, another load portion can be transmitted to the communication device, and when the load portion has not been correctly saved in the FLASH memory, the load portion can be re-transmitted to the communication device.

[0025] Some embodiments of the invention include monitoring a download status of the updated firmware load to the communication device. In such cases, monitoring the download status may comprise maintaining a database including a sequence number of a load portion correctly saved in the FLASH memory and incrementing the sequence number as each successive load portion is correctly saved in the FLASH memory.

[0026] In some embodiments of the invention, the second portion comprises a first Update Page and a second Update Page, the updated firmware load being stored in a selected one of the first and second Update Pages. In such cases, it is preferable that successive updated firmware loads are alternately saved in the first and second Update Pages. An active page flag may be defined and adapted to point to a selected one of the first and second Update Pages, the selected one of the first and second Update Pages being an active page, and the other one of the first and second Update Pages being an inactive page. The updated firmware load may be saved in the inactive page.

[0027] Some embodiments of the invention comprise the further step of determining whether or not a complete updated firmware load has been successfully saved in the inactive page. When the updated firmware load has been successfully saved in the inactive page, the active page flag may be modified to point to the inactive page, whereby the inactive page will become the active page upon a subsequent re-boot of the communication device.

[0028] In some embodiments of the invention, a re-boot of the communication device may be performed. In such cases, the step of performing a re-boot of the communication device may comprise accessing the active page to determine the presence of a valid firmware load. If a valid firmware load is located in the active page, operation of the communication device continues under control of the firmware load in the active page. If a valid firmware load is not located in the active page, the inactive page is accessed to determine the presence of a valid firmware load. If a valid firmware load is located in the inactive page, operation of the communication device continues under control of the firmware load in the inactive page, and the active page flag is modified to point to the inactive page, whereby the inactive page will become the active page upon a subsequent re-boot of the communication device. If a valid firmware load is not located in the inactive page, operation of the communication device continues under control of the first firmware load in the first portion.

[0029] The active page flag may be saved at a predetermined address in the second portion of the FLASH memory. In such cases, the predetermined address is preferably not in either the first or the second Update Pages.

[0030] In embodiments of the present invention, the firmware includes program code responsive to commands received from the manufacturer to begin an update procedure. The update procedure controls the communication device to perform the above-noted steps, substantially without interrupting user-initiated communication sessions.

[0031] In embodiments of the invention, the FLASH memory is divided into a Boot Page, and at least a First and a Second Update Pages. A "boot" version of the firmware may be installed in the Boot Page at the factory, and is never updated. Updated firmware loads are preferably saved only in the First and Second Update Pages. Accordingly, if a subsequent attempt to update the firmware fails, at least the "boot" version of the firmware will remain in uncorrupted condition, and can be used for operation of the communication device. Similarly, successive updates of the firmware may be alternately saved in the first and second Update Pages, so that if an attempted update of the firmware fails, the next most recently updated version of the firmware remains uncorrupted and is available for use. An Active Page Flag may be stored in the FLASH memory to identify which of the First and Second Update Pages contains the most up-to-date version of the firmware.

[0032] In embodiments of the present invention, after completion of the update procedure, the updated version of the firmware may become active upon a subsequent reboot of the communication device. In one embodiment, this may be accomplished by the user during their normal use of the communication device: that is, by powering down and later re-booting their PC. In an alternate embodiment, communication device reboot may be accomplished automatically as a final step in the update procedure. Automatic reboot is particularly suitable with xDSL communication devices, because the reboot will generally take less that one or two seconds, and the communication device can automatically re-establish its connection with the CO. The CO will detect the brief interruption in the connection, but will not disconnect any ongoing communication sessions (due to its short duration). Thus the communication device can be rebooted with the updated firmware without disrupting any communication sessions of the user. Depending on the type and data traffic of the communication session being engaged in, the user may not even be aware that the reboot has taken place.

[0033] A preferred embodiment of present invention includes a system for remotely updating firmware saved in a

FLASH memory of a communication device connected to a network, the FLASH memory being partitioned into at least a first and a second portion, a first firmware load being stored in the first portion. The system comprises: a server operatively connected to the network and adapted for transmitting at least a portion of an updated firmware load through the network to the communication device; a buffer for temporarily storing the transmitted portion of the updated firmware load; and a microprocessor operative under control of the first firmware load to: copy at least a portion of the first firmware load into a random access memory (RAM) of the communication device; trigger execution of the copied portion of the first firmware load from the RAM; and save the transmitted portion of the updated firmware load to the second portion of the FLASH memory under control of the copied portion of the first firmware load.

[0034] Another preferred embodiment of the present invention includes a communications device connected to a network and operative in accordance with firmware saved in a FLASH memory of a communication device, the FLASH memory being partitioned into at least a first and a second portion, a first firmware load being stored in the first portion. The communication device is adapted to enable remote update of the firmware through the network, and comprises: a buffer for temporarily storing a received portion of an updated firmware load; and a microprocessor operative under control of the first firmware load to: copy at least a portion of the first firmware load into a random access memory (RAM) of the communication device; trigger execution of the copied portion of the first firmware load from the RAM; and save the received portion of the updated firmware load to the second portion of the FLASH memory under control of the copied portion of the first firmware load.

BRIEF DESCRIPTION OF THE DRAWINGS

[0035] The invention will now be explained by way of example only and with reference to the following drawings, wherein:

Fig. 1 is a schematic diagram illustrating a communication device, and its connection to an update server at a manufacturer's site in accordance with an embodiment of the present invention;

Fig. 2 is an exemplary memory map of a firmware load stored in a 32kb memory page;

Fig. 3 is an exemplary memory map of a 128kb FLASH memory divided into four pages;

Fig. 4 is a flow chart showing the start-up processing following a (cold or warm) boot of the communication device;

Figs. 5a and 5b are flow charts illustrating respective alternative methods of updating firmware in accordance with the present invention;

Figs. 6a-6b are a flow chart illustrating In-band download of a firmware load in accordance with an embodiment of the present invention; and

Figs. 7a-7c show a flow chart illustrating Out-of-Band download of a firmware load in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0036] The present invention will now be described by way of a detailed description of a preferred embodiment, which is presented by way of example only, and is not intended to be limitative of the present invention, the features of which are defined in the appended claims.

[0037] As shown in Fig. 1, a communication device 1 usable with the present invention comprises a network interface 2 for interfacing with the network 4, a microprocessor 6 for controlling the operation of the communication device 1; a FLASH memory 8 for storing firmware; and RAM 10 used for storing run-time data as well as up-stream and down stream communication buffers (not shown) . In the illustrated embodiment, the communication device 1 is operatively connected to a host computer 12 via the network interface 2. In use, the microprocessor 6 operates in accordance with the firmware to provide the functionality of the communication device 1 (e.g. to transport information between the host computer 12 and the network 4).

[0038] The communication device 1 is operatively connected to a central office (CO) 14 providing access to the network 4 in a conventional manner. Communications sessions can therefore be established between the communication device 1 and other devices connected to the network 4 (with the communication device 1 initiating or terminating communication sessions), again in a conventional manner. In Fig. 1, an update server 16 at a manufacturer's site 18 is connected to the network 4 (in a conventional manner) and is capable of initiating a communication session with the communication device 1 as will be described in greater detail below.

[0039] Fig. 2 schematically illustrates an exemplary firmware load 20 which is conveniently separated into a boot logic 22 and an application logic 24. The boot logic 22 comprises instructions which are executed upon initial start-up of the communication device 1, including low-level operating parameters of the communication device 1. The boot logic 22 is arranged so that its start address 24 is at a predetermined fixed start address 26, so that at start-up, it can be directly accessed by the microprocessor 6. Execution of the boot logic 22 provides the microprocessor 6 with the necessary address information for continued operation. The application logic 24 comprises a plurality of programmed procedures, accessible using a high level Application Program Interface (API), for controlling the functionality of the communication device 1. Thus devices external to the communication device 1 (i.e. the host computer 12; the CO 14; etc.) can interact with the communication device 1 by means of the API. For example, a communications application (e.g. a web browser) resident in the host computer 12 can interact with the communication device 1 to establish a data connection with the network 4, and to up-load and down-load data. Similarly, the CO 14 can interact with the communication device 1 to negotiate transmission power settings, establish communication sessions, verify transmission of data packets, etc. The above-noted descriptions of the communication device 1 and firmware 20 are known, and their implementation is well understood by those skilled in the art.

[0040] In accordance with the present invention, the FLASH memory 8 is divided into a plurality (preferably four) of pages 28-34, which are conveniently of equal size. In the illustrated embodiment, a 128kb FLASH memory 8 is divided into four 32 kb pages 28-34, as shown in Fig. 3. Each page is capable of storing a complete firmware load 20, and is utilized as follows:

Page	Description
Boot Page (28)	Contains an original version of the firmware.
First Update Page (30)	Used to store an updated version of the firmware
Second Update Page (32)	Used to store an updated version of the firmware
Spare Page (34)	Used to store an Active Page flag

[0041] As indicated above, The Boot Page 28 contains a complete original firmware load 20a, including boot logic 22a and application logic 24a. This original firmware load 20a is installed and verified at the factory during manufacture of the communication device 1, and is never modified thereafter. Accordingly, if subsequent attempts to load updated versions of the firmware fail (and also prior to receipt of any updated versions), then the communication device 1 can operate using the original firmware load 20a stored in the Boot Page 28. The start address 26a for the original boot logic 22a is predetermined, so that the microprocessor 6 can access the original boot logic 22a stored in the Boot Page 28 upon start-up. Thus start-up of the communication device 1 is always executed on the basis of the original boot logic 22a installed by the factory.

[0042] The First and Second Update Pages 30, 32 are used to store updated firmware loads 20b, 20c. As shown in Fig. 3, the First and Second Update Pages 30, 32 are the same size as the boot page 30, and thus each page 30, 32 is capable of storing a complete firmware load (boot logic 22 and application logic 24). However, as noted above, only the original boot logic 22a (stored in the Boot Page 28) is used during start-up of the communication device 1. Accordingly, updated firmware loads 20b, 20c, which are subsequently downloaded and saved into the Update Pages 30, 32, may or may not contain a boot logic 22 section, as desired.

[0043] The Spare Page 34 is preferably not used for storing firmware loads 20. Instead, the Spare Page 34 is preferably used to store an Active Page Flag 36 which acts as a pointer to the active page. In the context of the present invention, the term "active page" refers to the Update Page (either one of the First or Second Update Pages) 30, 32 of the FLASH memory 8 which contains the application logic 24 used during run-time of the communication device 1. Normally, the active page will contain the most recently updated firmware load 20. The term "inactive page" refers to the other Update Page 30, 32 which is not pointed to by the Active Page Flag. The inactive page may be empty; contain an incomplete or corrupted firmware load 20; or may contain an obsolete firmware load 20 that has been superseded by a more recently updated firmware load 20 saved in the active page. In an embodiment of the present invention, the Active Page Flag 36 is a conditional value which allows firmware logic to enable (or access) the active page. For example: if the Active Page Flag 36 is set to a value of "1", then the firmware logic determines that the active page is the first Update Page 30; otherwise (i.e. if the Active Page Flag 36 is set to any other value) the firmware logic determines that the active page is the second Update Page 32. Alternatively, the value of the Active Page Flag 36 could be a pointer to the active page (e.g. containing the page-select signal used by the microprocessor 6 to enable the desired page of the FLASH memory).

[0044] In accordance with an embodiment of the present invention, each firmware load 20 is provided with a check-sum value 38 and a jump-code 40, in addition to the boot logic 22 and application logic 24 (See Fig. 2). Both of the check-sum value 38 and the jump-code 40 are stored at respective predetermined addresses, which preferably remain unchanged in all subsequent update versions of the firmware load 20. The check-sum value 38 is used to determine the integrity of the respective firmware load 20, as will be described in greater detail below. The jump code 40 is a pointer to the start address 42 of the respective application logic 24, and will normally be unique for each version of the firmware load 20. The purpose of the jump code 40 is that, because its location is predetermined, the original version boot logic 22a can access the jump code 40 in the active page and thereby determine a start address 42 for the respective application logic 24, irrespective of changes to the start address 42 effected by an update of the application logic 24.

[0045] Fig. 4 illustrates the method by which the original version boot logic 22a uses the Active Page Flag 36, check-sum 38 and jump code 40 to access, verify and begin execution of the appropriate application logic 24. The steps in the process are as follows:

401. On a reset of the communication device 1 (e.g. either a warm or cold boot), the microprocessor 6 enables the Boot Page 28 and begins execution of the original version boot logic 22a starting at the start address 26a;

402. the boot logic 22a retrieves the Active Page Flag 36 from the Spare Page 34 of the FLASH memory 8; identifies the active page on the basis of the Active Page Flag 36; and then causes the microprocessor 6 to enables the active page of the FLASH memory 8;

403. the check-sum value 38 of the active page is checked in a conventional manner;

404. If the active page check-sum value 38 is valid, then execution of the application logic 24 begins at the address 42 targeted by the active page jump-code 40;

405. If the active page check-sum value is invalid, then the microprocessor 6 enables the inactive page;

406. the check-sum value 38 of the inactive page is then checked in a conventional manner;

407. If the inactive page check sum value 38 is valid, then the microprocessor 6 sets the Active Page Flag 36 to point to the inactive page for future reboots (i.e. the inactive page is designated as the active page), and then execution of the application logic 24 begins at the start address 42 targeted by the jump-code 40.

408. If the inactive page check sum value 38 is invalid, then the microprocessor 6 enables the Boot Page 28 and begins execution of the boot page application logic 24a at the start address 42a targeted by the boot page jump-code 40a.

[0046] In addition to programmed routines for controlling communications functionality of the communication device 1, the application logic 24 in accordance with the invention includes procedures for managing the FLASH memory 8, and for writing data to the FLASH memory 8. Accessed using the API, these procedures permit the firmware 20 to be updated under the control of either the host computer 12 or through the network 4 by an update server 16 at the manufacturer's site 18 (Fig. 1). Exemplary API commands for accessing this functionality are shown in Table 1 below. It should be understood that Table 1 below is exemplary only, and is not necessarily comprehensive.

Table 1

Code	Data	Argument	Description
Dnld Clr	-	-	clears the inactive page of the FLASH memory 8.
DnldData	addr/data	sequence #	Writes data to the FLASH memory 8 starting at an address specified by addr

Table 1 (continued)

Code	Data	Argument	Description

DnldEth	-	cmd	Controls In-band download of firmware using the data channel (see detailed description below).
			cmd=0 : get status
			cmd=1 : In-band prep.
			cmd=2 : In-band verify
			cmd=3: : In-band copy
			cmd=4 : compare buffer to FLASH memory 8
			cmd=5 : query "In-band copy done?"

SwapApp	-	-	Verifies contents of the inactive page and sets the Active Page Flag to point to it.

[0047] As noted above, it is not possible to change the active page or write data to the FLASH memory 8 while it is active. However, because the microprocessor 6 can only execute one command at a time, execution of any command automatically causes any other concurrent processes to be temporarily held, and process-specific state-variables stored in a buffer (conventionally provided in the microprocessor 6 for that purpose) pending completion of the command currently being executed. In accordance with the present invention, this (conventional) operation of the microprocessor 6 is exploited to enable manipulation and writing of data to the FLASH memory 8 during run-time of the application logic 24 from the FLASH memory 8. Accordingly, the invention provides a layered operational structure described below with reference to Figs. 5a and 5b. In the embodiment illustrated in Fig. 5a, a block of application logic 24 is copied to RAM and executed by a shell routine. In the embodiment illustrated in Fig. 5b, a block of application logic 24 is copied to RAM 10 during start-up of the communication device 1, and remains resident in RAM 10 pending execution under control of the shell routine. For ease of illustration, both layer structures are illustrated in Figs. 5a and 5b by way of example algorithms which save data to the inactive page of the FLASH memory 8. It will be understood, however, that other operations can also be performed, as desired, using the layered structure of the invention. Referring now to Fig. 5a, saving data to the inactive page of the FLASH memory 8 proceeds as follows:

501. Reception of an API command (e.g. from the update server 16) causes execution of a shell routine from the FLASH memory 8;

502. The shell routine copies a block of application logic 24 into RAM 10, and then triggers execution of the copied application logic. Execution of the copied application logic from RAM 10 automatically causes other ongoing processes (controlled by application logic 24 in the FLASH memory 8) to be temporarily suspended, thereby releasing the FLASH memory 8 without terminating other processes.

503. The copied application logic in RAM 10 causes the microprocessor 6 to enable the inactive page of the FLASH memory 8, performs one or more operations on the inactive page of the FLASH memory 8 (e.g. writing bytes of an updated firmware load 20); and then causes the microprocessor 6 to enable the active page of the FLASH memory 8 before terminating.

504. Termination of the copied application logic in RAM 10 returns control to the shell routine running in the FLASH memory 8, and releases the RAM 10 occupied by the copied application logic. The shell routine may issue a response to the API command, prior to terminating.

[0048] Following termination of the shell routine, suspended processes can resume on the basis of their respective state variables. The shell routine can copy the entire application logic 24 to RAM 10, or only that portion required to execute the functionality accessed by the respective API command, as desired.

[0049] Fig 5b illustrates an alternative layered structure. In this case, a block of application logic 24 is copied into RAM 10 during start-up of the communication device 1, rather than by the shell routine. The copied block of application logic 24 remains resident in RAM 10, and is triggered by a command (possibly including one or more arguments) from the shell routine. Preferably, the copied block of application logic 24 completes a single operation step (i.e. it does not contain decision or process control logic) so that process control remains with the shell routine. This minimizes the size and run-time of the copied block of application logic 24, so that disruption of other concurrent processes (which are interrupted while the copied block of application logic 24 is running from RAM 10) is also minimized.

[0050] In the example illustrated in Fig. 5b, the copied block of application logic 24 is a "Copy-address" function which receives a target address of the FLASH memory 8 as an argument, and copies a block of data from a buffer to the inactive page of the FLASH memory 8 starting at the target address. The copied block of data may be as small as a single byte, or larger, as desired. As shown in Fig. 5b, using this alternative arrangement, saving data to the FLASH memory 8 proceeds as follows:

505. Reception of an API command (e.g. from the update server 16) causes execution of the shell routine from the FLASH memory 8;

506. The shell routine selects an address of the FLASH memory 8 to be written, and then triggers execution of the copied "Copy-address" logic, using the selected address as an argument. Execution of the "Copy-address" logic from RAM 10 automatically causes other ongoing processes (controlled by application logic 24 in the FLASH memory 8) to be temporarily suspended, thereby releasing the FLASH memory 8 without terminating other processes.

507. The "Copy-address" logic in RAM 10 causes the microprocessor 6 to enable the inactive page of the FLASH memory 8, performs one or more operations on the inactive page of the FLASH memory 8 (e.g. writing bytes of an updated firmware load 20 to the FLASH memory 8 starting at the selected address); and then causes the microprocessor 6 to enable the active page of the FLASH memory 8 before terminating.

508. Termination of the "Copy-address" logic in RAM 10 returns control to the shell routine running in the FLASH memory 8, while leaving the "Copy-address" logic resident in the RAM 10 for future use. The shell routine then determines if the operation is complete.

509. If the result of the check at step 508 above is "YES", the shell routine may issue a response to the API command, prior to terminating. Alternatively, if the result of the check at step 508 above is "NO", the shell routine loops back to select a new address and re-trigger the "Copy-address" logic.

[0051] Using the layered structure as described above with reference to Figs. 5a and 5b, updated firmware loads 20 can be downloaded and to the communication device 1 and saved in the inactive page of the FLASH memory 8 according to two modes, as described below. In the following two examples, the layered structure of Fig. 5a is used. It will be understood, however, that the same modes of operation can equally be implemented using the layered structure of Fig. 5b.

Mode 1: In-band Download

[0052] In-band download utilises a data-channel of the communication device 1 to receive the updated firmware load 20. The updated firmware load 20 is stored in a buffer of the communication device 1 pending copying of the updated firmware load 20 to the FLASH memory. Referring to Figs. 6a-6b, In-band download proceeds as follows:

601 The update server 16 transmits an In-band Prep. (DnldEth, cmd=1) message to the communication device 1 using the communication device's messaging channel. In response to the In-band Prep. message, the communication device 1 resets the upstream buffers and enters a loop-back mode.

602 The update server 16 then transmits the updated firmware load 20 over the data-channel, which is received and saved in the communication device's upstream buffer. On receipt of the firmware load 20, the communication device 1 performs a check-sum operation on the firmware load 20 to verify correct transmission, and transmits the result to the update server 16.

603 If the result of the check-sum operation is correct, the update server 16 transmits an In-Band Copy-to-FLASH command (DnldEth, cmd=3) over the communication device's message channel. This causes a shell routine to copy a block of Application logic 24 to the RAM 10 and then trigger execution of the copied application logic 24. The copied application logic causes the microprocessor to enable the inactive page of the FLASH memory 8; then copies the updated firmware load 20 from the upstream buffer and into the inactive page; and finally re-enables the active page before returning control to the shell routine and terminating.

604 While In-Band Copy operation (step 603) is in progress, the update server 16 periodically (e.g. every 2-3 seconds) sends an "In-band Copy Done query" (DnldEth, cmd=5) to the communication device 1. However, since the copied application logic 24 running in the RAM 10 is not responsive to this query (because it only contains logic

for copying data from the upstream buffers to the inactive page), no response to the query is returned to the update server 16 until the In-Band Copy operation is completed and the active page of the FLASH memory 8 is re-enabled. Control then returns to the application logic 24 running in the FLASH memory 8. At this point, the "In-band Copy Done query" (DnldEth, cmd=5) is acknowledged by returning the query to the update server 16, which notifies the update server 16 that the copy operation has been completed.

605 The update server 16 then transmits a "SwapApp" command, which causes the communication device 1 to set the Active Page Flag 36 to point to the just updated inactive page, so that on a future re-boot of the communication device 1 the boot logic 22a will start the application logic 24 of the updated firmware load 20. In an embodiment of the invention, the "SwapApp" command can also trigger a re-boot of the communication device 1.

[0053] In-Band download facilitates a very rapid transmission of an updated firmware load to the communication device 1. For example, a 20kb firmware load can be transmitted to the communication device 1 in as little as 0.17 sec. This makes transmitting an updated firmware load 20 rapid and convenient for the manufacturer. However, copying the updated firmware load 20 to FLASH memory 8 is expected to take significantly longer (a 32kb load can require as much as 15 seconds to copy). Because data channel and the upstream buffers are used to transfer the updated firmware load 20, the communication device 1 must first enter a loop-back mode, which necessarily interrupts other data traffic. The communication device 1 cannot be returned to normal operation until the copy operation is completed, so an associated interruption in communications may be experienced by the user.

Mode 2: Out of Band Download

[0054] Out of Band download utilises the communication device 1's message-channel and buffers to download the updated firmware load. Referring to Figs. 7a-7c, Out of band download proceeds as follows:

701. The update server 16 transmits an "DnldClr" message to the communication device 1 using the communication device's messaging channel. In response to the "DnldClr" message, the communication device 1 starts a shell routine which copies a block of application logic 24 to the RAM 10 and triggers execution of the copied application logic from the RAM 10. The copied application logic causes the microprocessor 6 to enable the inactive page of the FLASH memory 8; initializes the inactive page of the FLASH memory 8 by writing a constant value (e.g. "0") into all locations of the inactive page; and then returns control to the shell routine before terminating.

702. The update server 16 then transmits a "DnldData" command over the message-channel which contains a sequence number, a start address, and at least a portion of an updated firmware load 20 as arguments.

703. On receipt of the "DnldData" command, the communication device 1 starts a shell routine which copies a block of application logic 24 to the RAM 10 and triggers execution of the copied application logic from the RAM 10. The copied application logic causes the microprocessor 6 to enable the inactive page of the FLASH memory 8; copies the bytes of the updated firmware load 20 included in the DnldData command into the inactive page of the FLASH memory 8 sequentially starting at the specified start address; and then returns control to the shell routine before terminating. The sequence number is not used as part of the save operation, but rather is passed back to the update server 16 by the shell routine as an argument in an acknowledgement message. When the acknowledgement (and sequence number) are received by the update server 16, the server is informed that the transmitted portion of the updated firmware load 20 was received correctly. At this point a further portion of the updated firmware load 20 can be transmitted by the update server 16 with the same sequence number or a new one. If the sequence number is not received by the update server 16, or it is received indicating an error condition, then the update server 16 retransmits the relevant portion of the updated firmware load 20 attached to a new "DnldData" command.

704. Steps 702 and 703 are repeated until the entire updated firmware load 20 has been correctly transmitted to the communication device 1 and saved in the FLASH memory 8.

705. Once the download process (steps 702-704) is completed, the update server 16 sends a "SwapApp" command, which causes the communication device 1 to set the Active Page Flag 38 to point to the inactive page (in which the updated firmware load 20 is saved) , so that on a future re-boot of the communication device 1 the boot logic 22a will access and start the application logic 24 of the updated firmware load 20. As noted above, the "SwapApp" command may also trigger re-boot of the communication device 1.

[0055] Out-of-Band download is significantly slower than In-band download, because an updated firmware load 20 must be broken up into small blocks which are transmitted individually. This is due to limitations in the size of the message channel buffer in the communication device 1 (typically 512 bytes). This slows down and complicates the transmission of the updated firmware load 20, because the update server must continuously monitor the status of the download. Additionally, the risk of an incomplete download is increased because it is possible that a user of the host computer 12 may power down the communication device 1 before the download is complete. However, because the message channel is used for the download, this process can be conducted simultaneously with data traffic of user-initiated communication sessions, and thus it is possible for the entire download operation to be completed without inconveniencing the user.

[0056] The risk of partial downloads can be managed by maintaining a database of each communication device 1 and a respective current download status. If such a database is maintained, each block of the updated firmware load 20 is assigned a unique sequence number used for the respective "DnldData" command, so that the download status for each communication device 1 may be tracked by the sequence number of the latest successfully completed "DnldData" command. As each acknowledgement message is received by the update server 16 (step 703), the database is updated with the sequence number of the latest successfully completed "DnldData" command. If the communication device 1 goes "off-line" or is powered down before the download is complete, then transmission of "DnldData" commands to the communication device 1 is terminated. When the communication device 1 becomes available at a later time, transmission of "DnldData" commands to the communication device 1 is resumed starting at the sequence number indicated in the database.

[0057] Thus it will be seen that the present invention provides a method and apparatus for remotely updating firmware saved in a FLASH memory of a communication device connected to a network. The FLASH memory is partitioned into at least a first and a second portion. A first firmware load is stored in the first portion. During run-time of the first firmware load, at least a portion of an updated firmware load is transmitted through the network to the communication device. The transmitted portion of the updated firmware load is temporarily stored in a buffer of the communication device. At least a portion of the first firmware load is copied into a random access memory (RAM) of the communication device. Execution, from the RAM, of the copied portion of the first firmware load is triggered. Under control of the copied portion of the first firmware load, the transmitted portion of the updated firmware load is saved to the second portion of the FLASH memory.

[0058] The embodiments of the invention described above are intended to be exemplary only. Changes and modifications will no doubt become apparent to those of skill in the art.

Claims

1. A method of remotely updating firmware saved in a FLASH memory of a communication device connected to a network, the FLASH memory being partitioned into at least a first and a second portion, a first firmware load being stored in the first portion, CHARACTERISED IN THAT the method comprises the steps of, during run-time of the first firmware load:

   a) transmitting at least a portion of an updated firmware load through the network to the communication device;

   b) temporarily storing the transmitted portion of the updated firmware load in a buffer of the communication device;

   c) copying at least a portion of the first firmware load into a random access memory (RAM) of the communication device;

   d) triggering execution of the copied portion of the first firmware load from the RAM; and

   e) under control of the copied portion of the first firmware load, saving the transmitted portion of the updated firmware load to the second portion of the FLASH memory.

2. A method as claimed in claim 1, CHARACTERISED IN THAT the first portion comprises a boot page, and the first firmware load is saved in the boot page during manufacture of the communication device.

3. A method as claimed in claim 1 or 2, CHARACTERISED IN THAT the first firmware load includes a boot logic adapted to control operation of the communication device during a start-up of the communication device.

4. A method as claimed in any one of claims 1, 2 or 3, CHARACTERISED IN THAT an entire updated firmware load is transmitted in a single download operation using a data channel of the communication device, and temporarily stored in an upstream buffer of the communication device.

5. A method as claimed in claim 4, further comprising a step of placing the communication device into a loop-back mode prior to transmitting the updated firmware load.

6. A method as claimed in any one of claims 1, 2 or 3, CHARACTERISED IN THAT the step of copying at least a portion of the first firmware load into a random access memory (RAM) of the communication device is performed during a start-up of the communication device.

7. A method as claimed in any one of claims 1, 2 or 3, further comprising preliminarily dividing the updated firmware load into a plurality of predetermined load portions.

8. A method as claimed in claim 7, CHARACTERISED IN THAT each load portion is transmitted in a respective download operation using a message channel of the communication device, and temporarily stored in a message buffer of the communication device.

9. A method as claimed in claim 8, CHARACTERISED IN THAT in each download operation comprises transmitting a DnldData command including an address and the load portion as arguments.

10. A method as claimed in claim 9, further comprising saving the load portion in the FLASH memory starting at an address of the FLASH memory corresponding to the address included in the DnldData command.

11. A method as claimed in claim 7, further comprising a step of determining whether or not the load portion has been correctly saved in the FLASH memory.

12. A method as claimed in claim 11, CHARACTERISED IN THAT when the load portion has been correctly saved in the FLASH memory, another load portion is transmitted to the communication device, and when the load portion has not been correctly saved in the FLASH memory, the load portion is re-transmitted to the communication device.

13. A method as claimed in claim 7, further comprising monitoring a download status of the updated firmware load to the communication device.

14. A method as claimed in claim 13, CHARACTERISED IN THAT monitoring the download status comprises maintaining a database including a sequence number of a load portion correctly saved in the FLASH memory and incrementing the sequence number as each successive load portion is correctly saved in the FLASH memory.

15. A method as claimed in any one of claims 1, 2 or 3, CHARACTERISED IN THAT the second portion comprises a first Update Page and a second Update Page, the updated firmware load being stored in a selected one of the first and second Update Pages.

16. A method as claimed in claim 15, CHARACTERISED IN THAT successive updated firmware loads are alternately saved in the first and second Undate Pages.

17. A method as claimed in claim 15, further comprising defining an active page flag adapted to point to a selected one of the first and second Update Pages, the selected one of the first and second Update Pages being an active page, and the other one of the first and second Update Pages being an inactive page.

18. A method as claimed in claim 17, CHARACTERISED IN THAT the updated firmware load is saved in the inactive page.

19. A method as claimed in claim 18, further comprising the step of determining whether or not a complete updated firmware load has been successfully saved in the inactive page.

20. A method as claimed in claim 19, further comprising, when the updated firmware load has been successfully saved in the inactive page, modifying the active page flag to point to the inactive page, whereby the inactive page will become the active page upon a subsequent re-boot of the communication device.

21. A method as claimed in claim 17, further comprising a step of performing a re-boot of the communication device.

22. A method as claimed in claim 21 CHARACTERISED IN THAT, the step of performing a re-boot of the communication device comprises the steps of:

a) accessing the active page to determine the presence of a valid firmware load;

b) if a valid firmware load is located in the active page, continuing operation of the communication device under control of the firmware load in the active page;

c) if a valid firmware load is not located in the active page, accessing the inactive page to determine the presence of a valid firmware load;

d) if a valid firmware load is located in the inactive page:

i) continuing operation of the communication device under control of the firmware load in the inactive page; and

ii) modifying the active page flag to point to the inactive page, whereby the inactive page will become the active page upon a subsequent re-boot of the communication device; and

e) if a valid firmware load is not located in the inactive page, continuing operation of the communication device under control of the first firmware load in the first portion.

23. A method as claimed in claim 17, further comprising saving the active page flag at a predetermined address in the second portion of the FLASH memory.

24. A method as claimed in claim 23, CHARACTERISED IN THAT the predetermined address is not in either the first or the second Update Pages.

25. An apparatus for remotely updating firmware saved in a FLASH memory of a communication device connected to a network, the FLASH memory being partitioned into at least a first and a second portion, a first firmware load being stored in the first portion, and at least a portion of an updated firmware load being transmitted through the network to the communication device, CHARACTERISED IN THAT a microprocessor is operative under control of the first firmware load to:

a) copy at least a portion of the first firmware load into a random access memory (RAM) of the communication device;

b) trigger execution of the copied portion of the first firmware load from the RAM; and

c) save the transmitted portion of the updated firmware load to the second portion of the FLASH memory under control of the copied portion of the first firmware load.

26. An apparatus as claimed in claim 25, CHARACTERISED IN THAT the communications device comprises a buffer for temporarily storing the transmitted portion of the updated firmware load.

27. An apparatus as claimed in claim 25, CHARACTERISED IN THAT the portion of an updated firmware load is transmitted through the network to the communication device by a server operatively connected to the network.

28. An apparatus as claimed in any one of claims 25, 26, and 27, CHARACTERISED IN THAT the first portion comprises a boot page, and the first firmware load is saved in the boot page during manufacture of the communication device.

29. An apparatus as claimed in any one of claims 25, 26, and 27, CHARACTERISED IN THAT the first firmware load includes a boot logic adapted to control operation of the microprocessor during a start-up of the communication device.

30. An apparatus as claimed in claim 27, CHARACTERISED IN THAT the server is adapted to transmit an entire updated firmware load in a single download operation using a data channel of the communication device.

31. A system as claimed in claim 30, CHARACTERISED IN THAT the microprocessor is operative under control of the first firmware load to place the communication device into a loop-back mode in response to a message transmitted by the server.

32. An apparatus as claimed in claim 27, CHARACTERISED IN THAT the server is adapted to preliminarily divide the updated firmware load into a plurality of predetermined load portions.

33. An apparatus as claimed in claim 32, CHARACTERISED IN THAT the server is adapted to transmit each load portion in a respective download operation using a message channel of the communication device.

34. An apparatus as claimed in claim 33, CHARACTERISED IN THAT the server is adapted to transmit a DnldData command including an address and the load portion as arguments during each download operation.

35. An apparatus as claimed in claim 34, CHARACTERISED IN THAT the microprocessor is operative under control of the copied portion of the first firmware load to save the load portion in the FLASH memory starting at an address of the FLASH memory corresponding to the address included in the DnldData command.

36. An apparatus as claimed in claim 32, further comprising means for monitoring a download status of the updated firmware load to the communication device.

37. An apparatus as claimed in claim 36, CHARACTERISED IN THAT the means for monitoring a download status of the updated firmware load to the communication device comprises:

a) a respective sequence number associated with each load portion transmitted by the server;

b) a database including, in respect of the communication device, the sequence number corresponding to a load portion correctly saved in the FLASH memory;

c) means for determining whether or not the load portion transmitted by the server has been correctly saved in the FLASH memory; and

d) means for updating the database as each successive load portion is correctly saved in the FLASH memory.

38. An apparatus as claimed in claim 37, CHARACTERISED IN THAT the database is stored on the server.

39. An apparatus as claimed in any one of claims 25, 26, and 27, CHARACTERISED IN THAT the second portion comprises a First Update Page and a Second Update Page, each of the First and Second Update Pages being adapted to store a respective updated firmware load.

40. An apparatus as claimed in claim 39, CHARACTERISED IN THAT the microprocessor is operative under control of the copied portion of the first firmware load to alternately save successive updated firmware loads in the First and Second Update Pages.

41. An apparatus as claimed in claim 40, further comprising an Active Page Flag adapted to point to a selected one of the First and Second Update Pages, the selected one of the First and Second Update Pages being an active page, and the other one of the First and Second Update Pages being an inactive page.

42. An apparatus as claimed in claim 41, CHARACTERISED IN THAT the microprocessor is operative under control of the copied portion of the first firmware load to save the updated firmware load in the inactive page.

43. An apparatus as claimed in claim 42, CHARACTERISED IN THAT the microprocessor is operative under control of the first firmware load to modify the active page flag to point to the inactive page in response to a message transmitted by the server, whereby the inactive page will become the active page upon a subsequent re-boot of the communication device.

44. An apparatus as claimed in claim 41, CHARACTERISED IN THAT, during a start-up of the communication device, the microprocessor is adapted to:

a) access the active page to determine the presence of a valid firmware load;

b) if a valid firmware load is located in the active page, continue operation of the communication device under control of the firmware load in the active page;

c) if a valid firmware load is not located in the active page, access the inactive page to determine the presence of a valid firmware load;

d) if a valid firmware load is located in the inactive page:

i) continue operation of the communication device under control of the firmware load in the inactive page; and

ii) modify the active page flag to point to the inactive page, whereby the inactive page will become the active page upon a subsequent re-boot of the communication device; and

e) if a valid firmware load is not located in the inactive page, continue operation of the communication device under control of the first firmware load in the first portion.

45. An apparatus as claimed in claim 41, CHARACTERISED IN THAT the active page flag is saved at a predetermined address in the second portion of the FLASH memory.

46. An apparatus as claimed in claim 45, CHARACTERISED IN THAT the predetermined address is not in either the first or the second Update Pages.

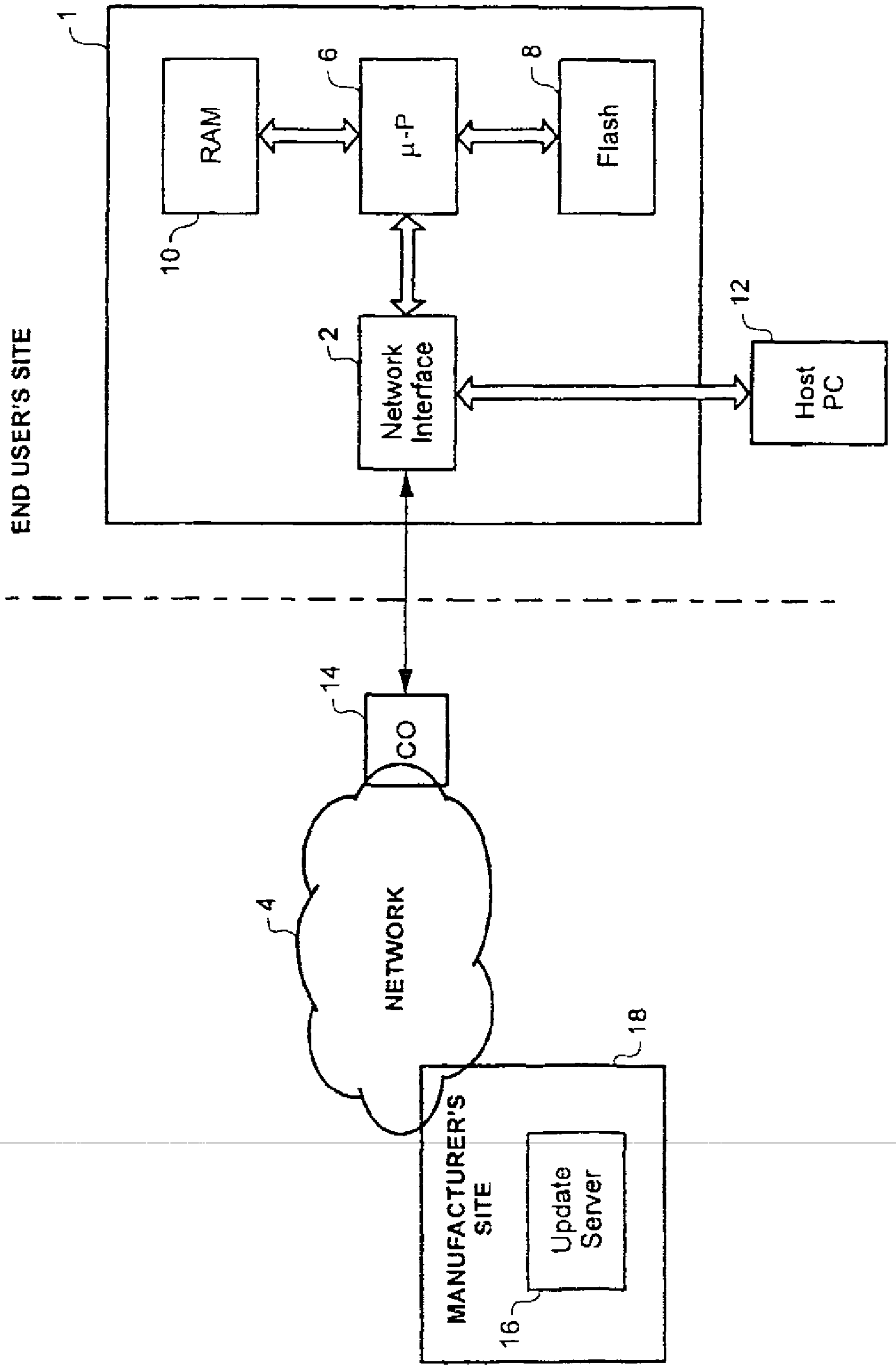

END USER'S SITE
1
RAM
10
μ-P
6
Flash
8
Network Interface
2
Host PC
12
CO
14
NETWORK
4
MANUFACTURER'S SITE
18
Update Server
16

Figure 1

Figure 2

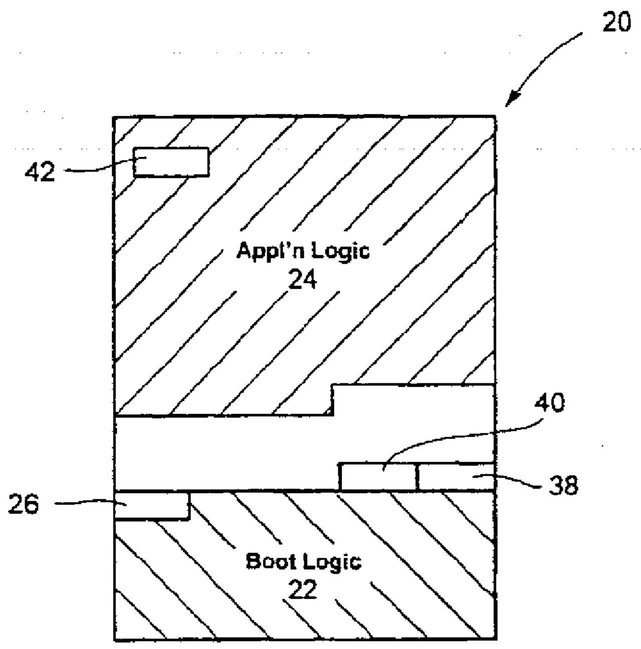


Figure 3

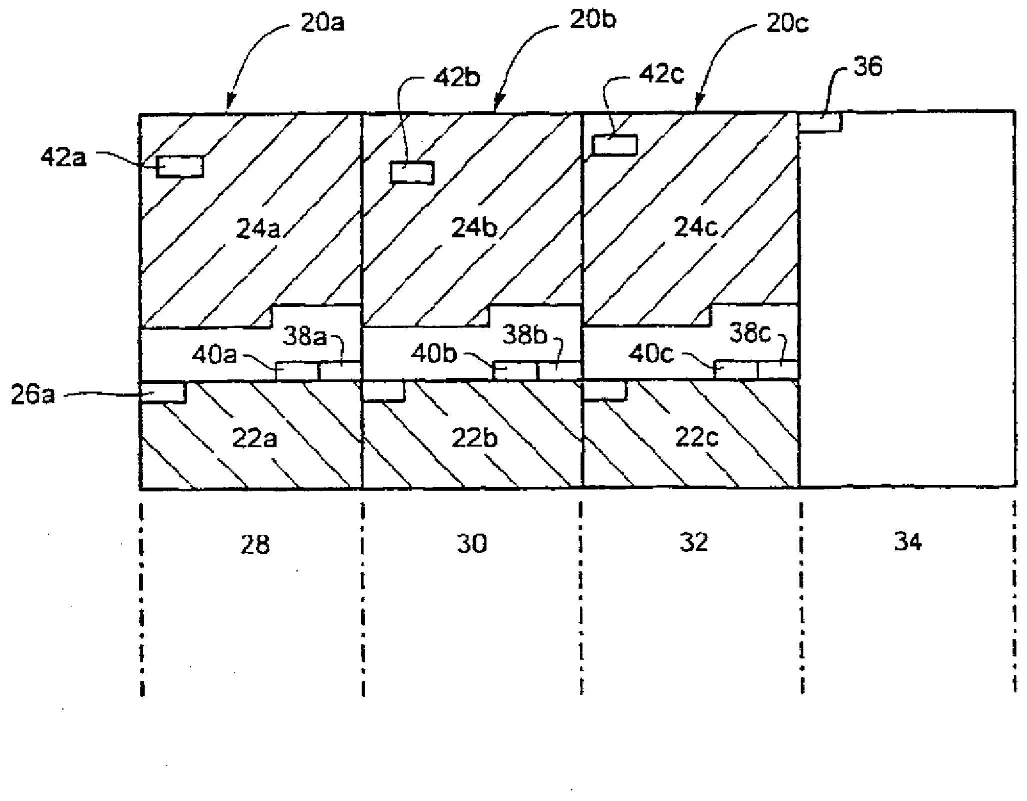


Figure 4

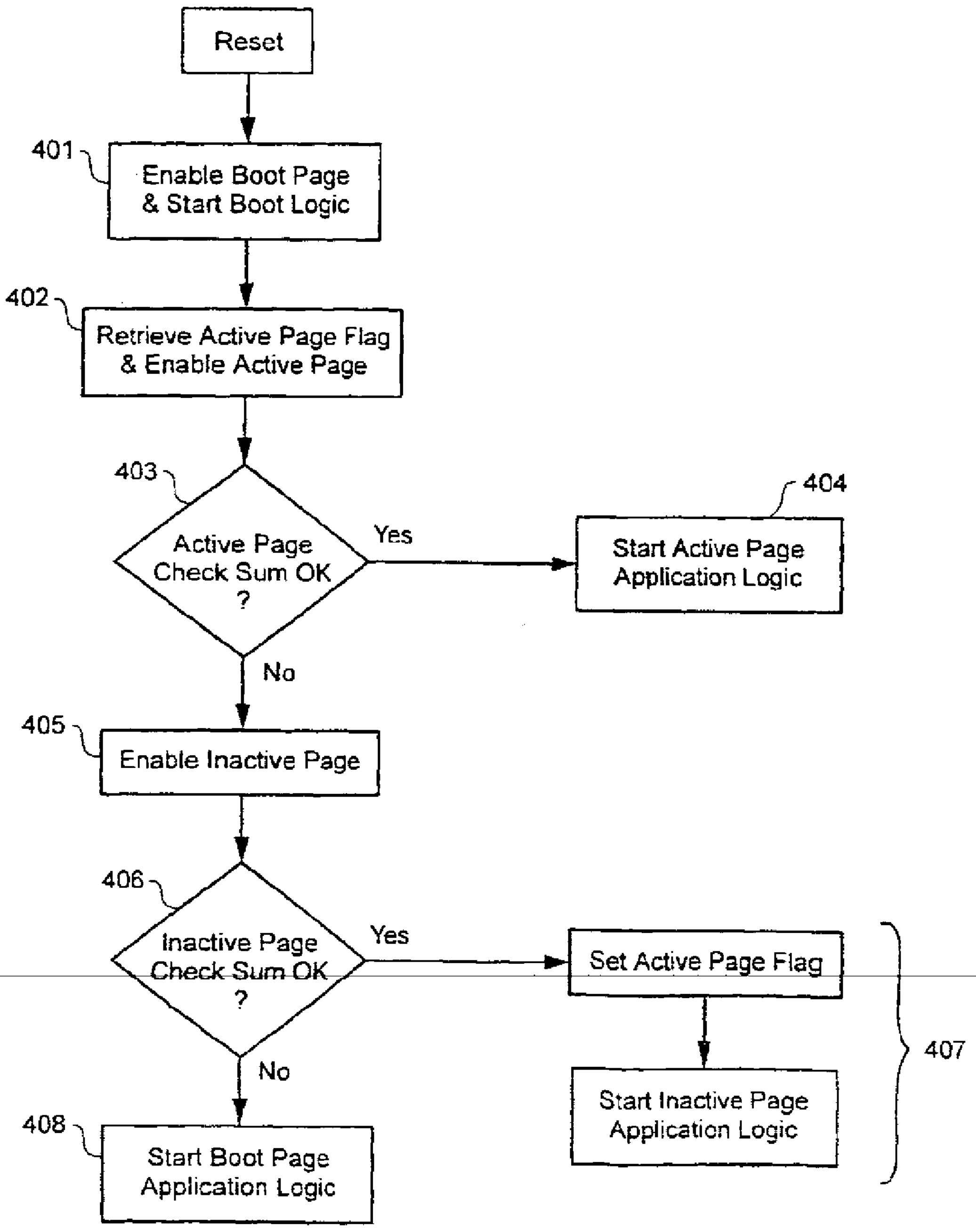

Reset
401
Enable Boot Page & Start Boot Logic
402
Retrieve Active Page Flag & Enable Active Page
403
Active Page Check Sum OK ?
Yes
404
Start Active Page Application Logic
No
405
Enable Inactive Page
406
Inactive Page Check Sum OK ?
Yes
Set Active Page Flag
Start Inactive Page Application Logic
407
No
408
Start Boot Page Application Logic

Figure 5a

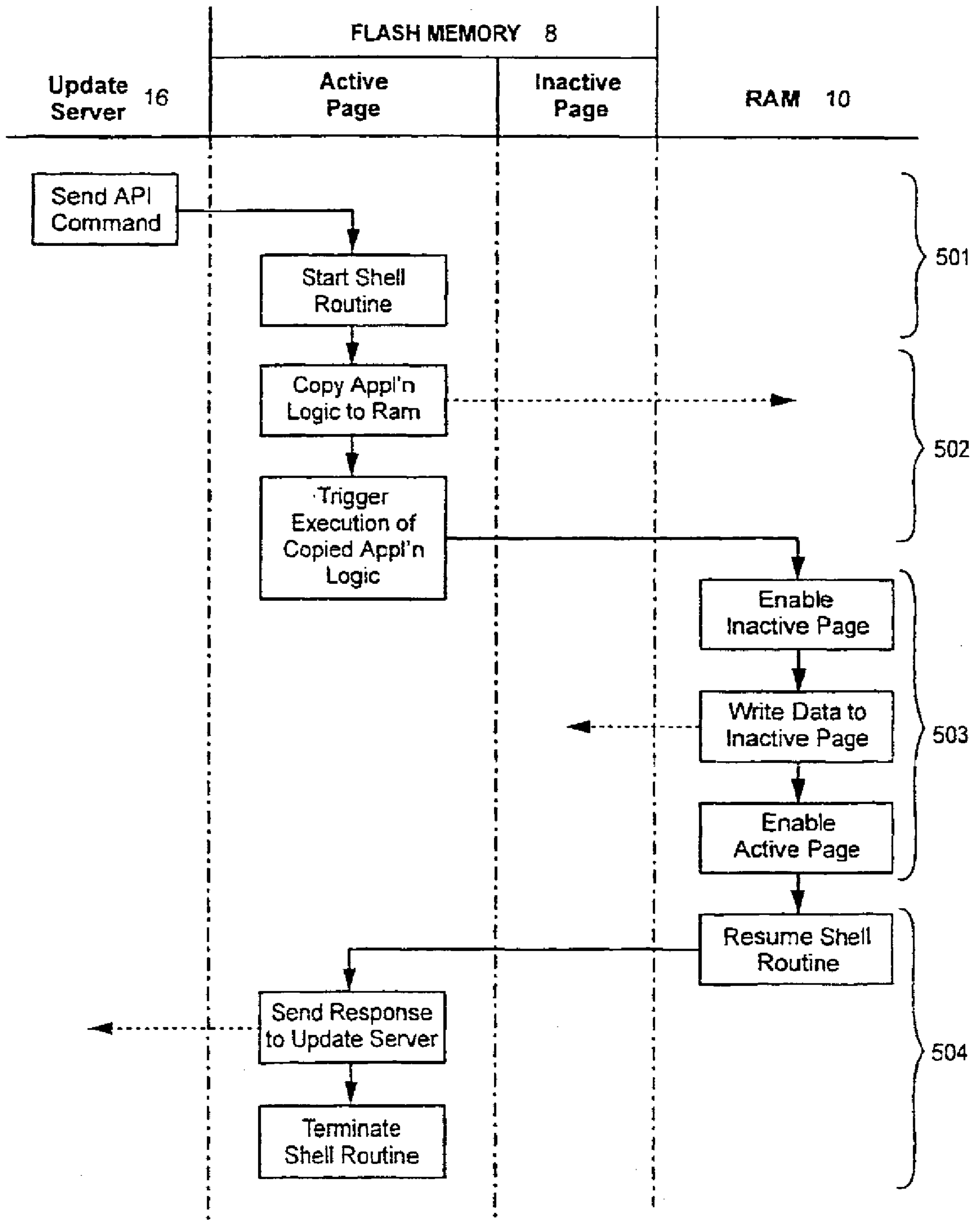

FLASH MEMORY 8
Update Server 16
Active Page
Inactive Page
RAM 10
Send API Command
Start Shell Routine
Copy Appl'n Logic to Ram
Trigger Execution of Copied Appl'n Logic
Enable Inactive Page
Write Data to Inactive Page
Enable Active Page
Resume Shell Routine
Send Response to Update Server
Terminate Shell Routine
501
502
503
504

Figure 5b

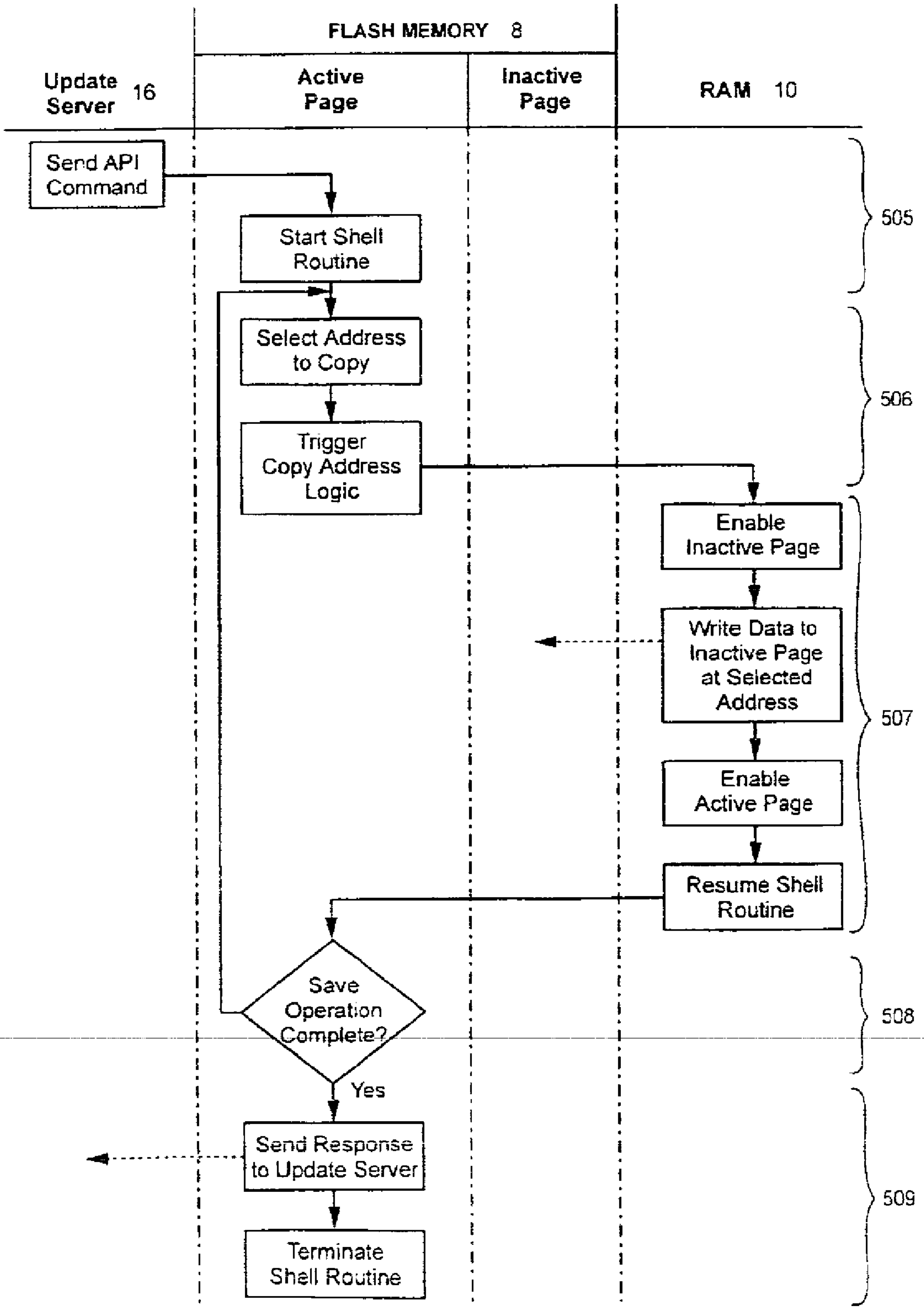

FLASH MEMORY 8
Update Server 16
Active Page
Inactive Page
RAM 10
Send API Command
Start Shell Routine
Select Address to Copy
Trigger Copy Address Logic
Enable Inactive Page
Write Data to Inactive Page at Selected Address
Enable Active Page
Resume Shell Routine
Save Operation Complete?
Yes
Send Response to Update Server
Terminate Shell Routine
505
506
507
508
509

Figure 6a

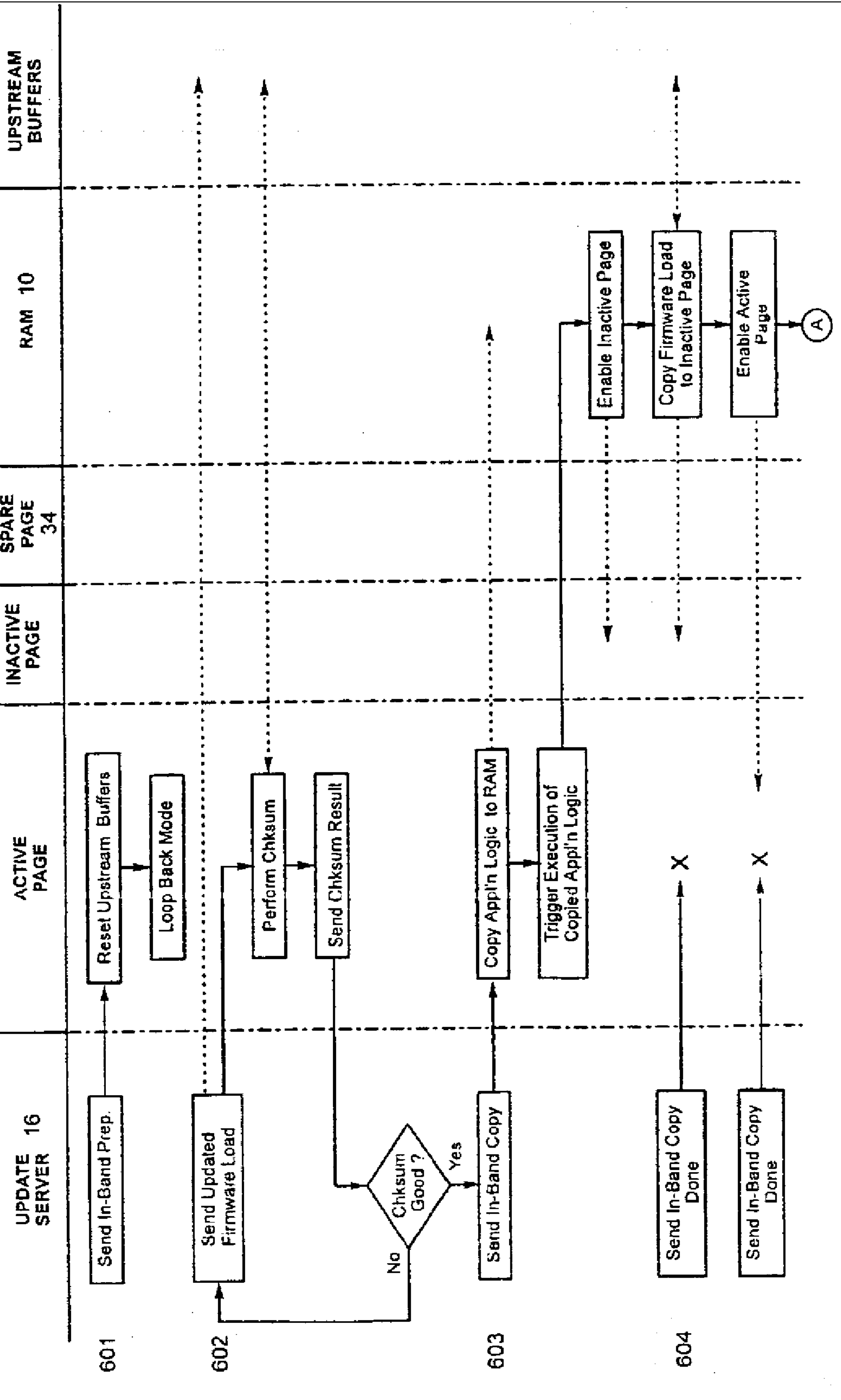

UPDATE SERVER 16
FLASH MEMORY 8
ACTIVE PAGE
INACTIVE PAGE
SPARE PAGE 34
RAM 10
UPSTREAM BUFFERS
601
Send In-Band Prep.
Reset Upstream Buffers
Loop Back Mode
602
Send Updated Firmware Load
Perform Chksum
Send Chksum Result
Chksum Good ?
No
Yes
603
Send In-Band Copy
Copy Appl'n Logic to RAM
Trigger Execution of Copied Appl'n Logic
Enable Inactive Page
Copy Firmware Load to Inactive Page
Enable Active Page
A
604
Send In-Band Copy Done
Send In-Band Copy Done
X
X

Figure 6b

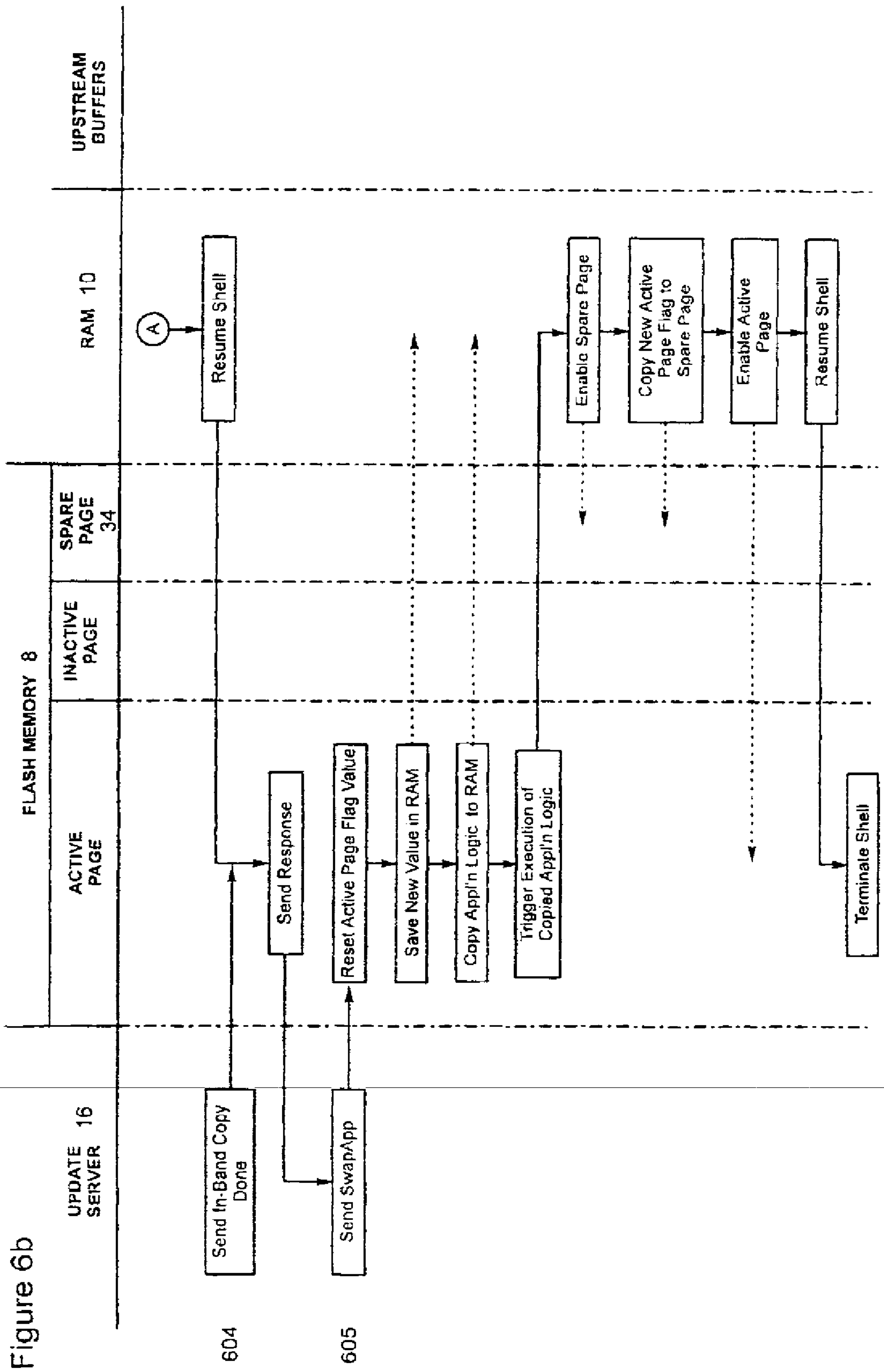
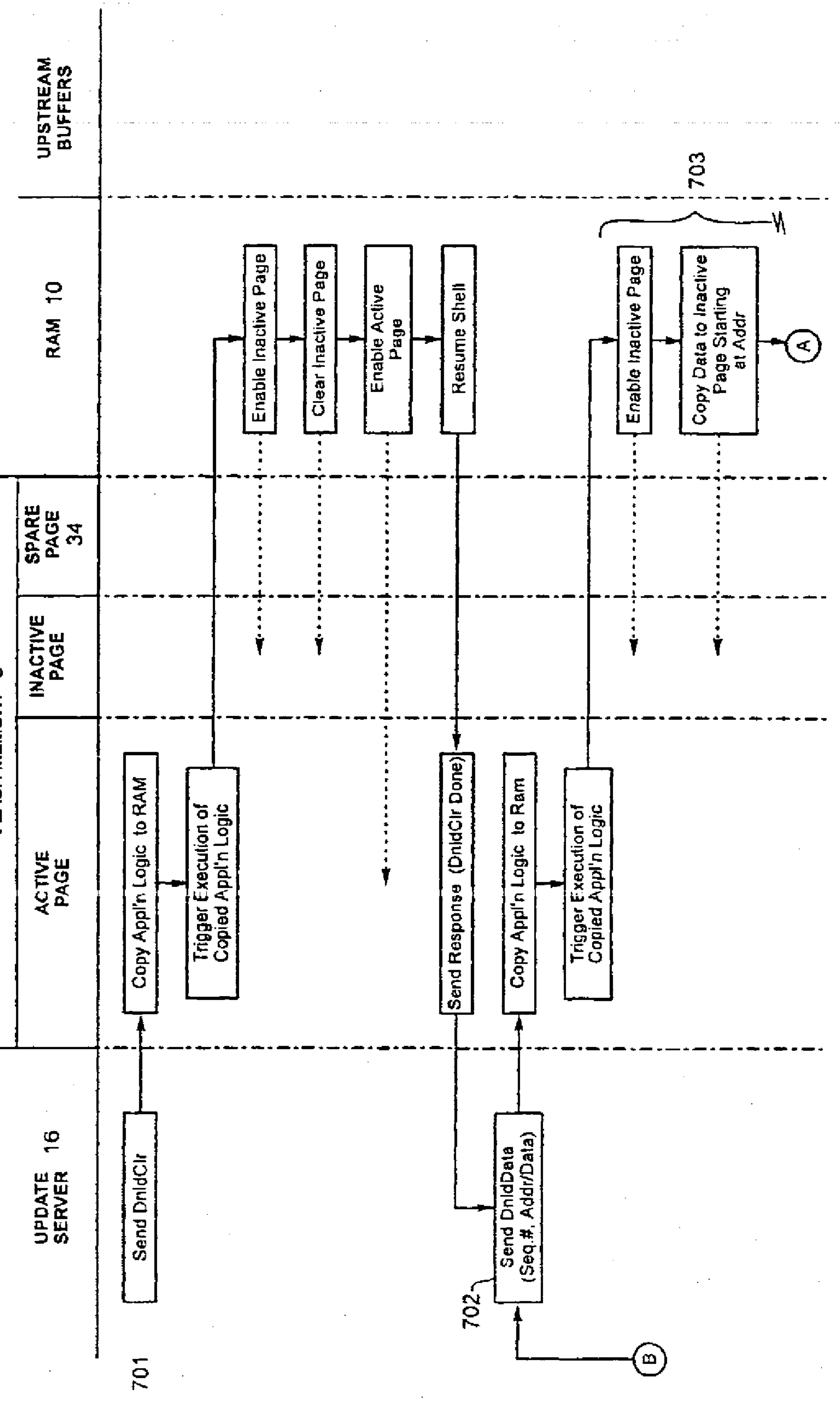

UPDATE SERVER 16
FLASH MEMORY 8
ACTIVE PAGE
INACTIVE PAGE
SPARE PAGE 34
RAM 10
UPSTREAM BUFFERS
604
605
Send In-Band Copy Done
Send SwapApp
A
Resume Shell
Send Response
Reset Active Page Flag Value
Save New Value in RAM
Copy Appl'n Logic to RAM
Trigger Execution of Copied Appl'n Logic
Enable Spare Page
Copy New Active Page Flag to Spare Page
Enable Active Page
Resume Shell
Terminate Shell

Figure 7a


UPDATE SERVER 16
FLASH MEMORY 8
ACTIVE PAGE
INACTIVE PAGE
SPARE PAGE 34
RAM 10
UPSTREAM BUFFERS
701
Send DnldClr
Copy Appl'n Logic to RAM
Trigger Execution of Copied Appl'n Logic
Enable Inactive Page
Clear Inactive Page
Enable Active Page
Resume Shell
Send Response (DnldClr Done)
702
Send DnldData (Seq.#, Addr/Data)
Copy Appl'n Logic to Ram
Trigger Execution of Copied Appl'n Logic
703
Enable Inactive Page
Copy Data to Inactive Page Starting at Addr
A
B

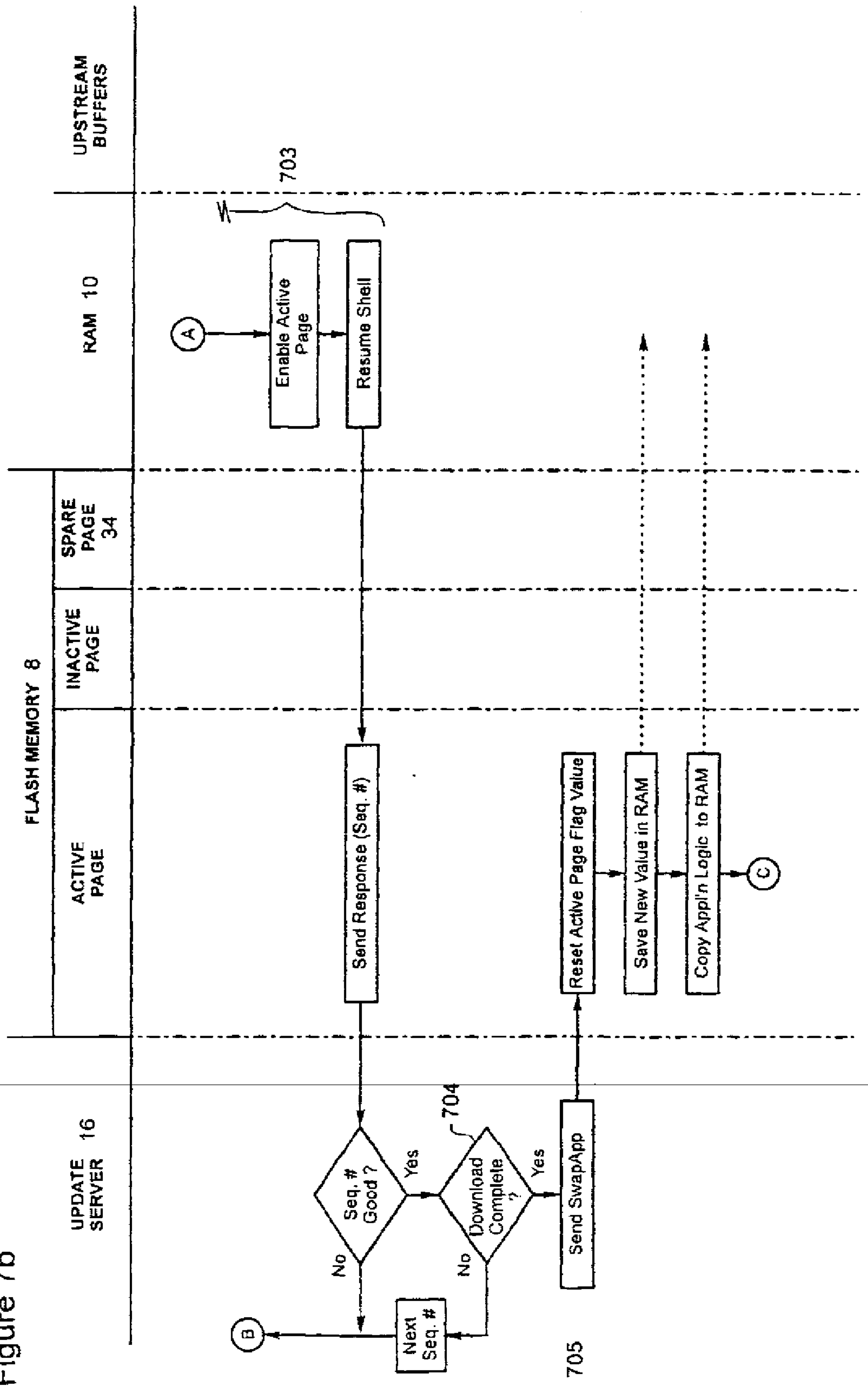

UPSTREAM BUFFERS
RAM 10
FLASH MEMORY 8
SPARE PAGE 34
INACTIVE PAGE
ACTIVE PAGE
UPDATE SERVER 16
703
A
Enable Active Page
Resume Shell
Send Response (Seq. #)
Seq. # Good ?
Yes
No
B
Next Seq. #
704
Download Complete ?
Yes
No
Send SwapApp
705
Reset Active Page Flag Value
Save New Value in RAM
Copy Appl'n Logic to RAM
C

Figure 7b

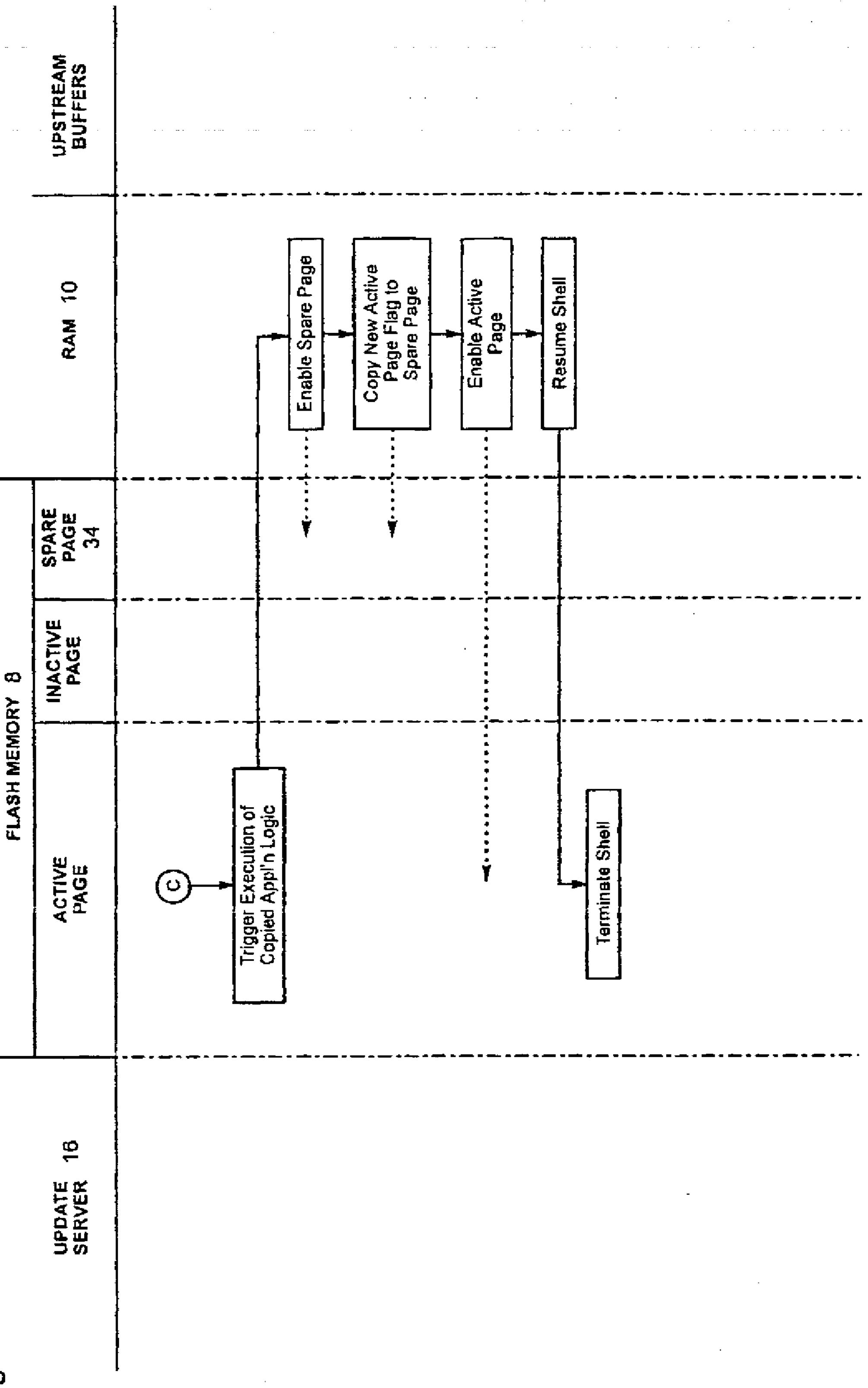

UPSTREAM BUFFERS
RAM 10
FLASH MEMORY 8
SPARE PAGE 34
INACTIVE PAGE
ACTIVE PAGE
UPDATE SERVER 16
C
Trigger Execution of Copied Appl'n Logic
Enable Spare Page
Copy New Active Page Flag to Spare Page
Enable Active Page
Resume Shell
Terminate Shell

Figure 7c